

A NEW GENUS AND SPECIES OF APHELINIDAE
WITH SOME SYNONYMIES, A REDIAGNOSIS OF
ASPIDIOTIPHAGUS AND A KEY TO PENTAMEROUS
AND HETEROMEROUS PROSPALTELLINAE
(HYMENOPTERA: CHALCIDOIDEA: APHELINIDAE)

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Abstract.—*Aleurodiphilus americanus*, n. gen., n. sp., is described. The systematic position of *Aleurodiphilus* in the subfamily Prospaltellinae is discussed and a key given for separation of the genera *Aleurodiphilus*, *Aspidiotiphagus* Howard, 1894, *Coccophagoides* Girault, 1915, *Encarsia* Foerster, 1878, and *Primaprospaltella* DeBach and LaSalle, 1981. Two additional species, *basicinctus* (Gahan) and *pergandiellus* (Howard), are placed under *Aleurodiphilus*. All *Aleurodiphilus* species are primary parasites of whiteflies (except for hyperparasitic males). Known distribution of the genus includes North, Central, and South America and the Caribbean.

The taxonomic standing and relationship of *Aspidiotiphagus* to *Aleurodiphilus* and *Encarsia* is discussed. Recognition characters for *Aspidiotiphagus* are given. All *Aspidiotiphagus* species are primary parasites of diaspidid scales. Known distribution of *Aspidiotiphagus* is worldwide.

A companion paper by DeBach and LaSalle (1981) helps clarify the *Encarsia-Prospaltella-Trichaporus* problem but does not resolve it entirely in our minds because for several years it has been our opinion that there is still another closely related but distinct and generally unrecognized natural group of species of whitefly parasites that have variously been placed under *Encarsia*, *Prospaltella*, or *Trichaporus*. Hayat (1976) recognized that such a group exists, and he included several *Encarsia* species in it but without giving it any formal designation. Viggiani and Mazzone (1979) suggested a *pergandiella* group of *Encarsia* for such forms but included only *E. pergandiella* Howard.

The existence of the natural group described here became evident to us over the past several years during our study of thousands of specimens of so-called *Encarsia* spp. or *Prospaltella* spp., plus a few *Trichaporus* spp.,

reared from the woolly whitefly, *Aleurothrixus floccosus* (Maskell) (Homoptera: Aleyrodidae), collected throughout the Americas, as well as from other whitefly species from various countries and from species descriptions in the literature. We consider that this rather uniform, generally easily distinguishable group of whitefly parasites deserves generic status as much as, or more so than, some closely related well-established genera.

Accordingly, we propose the new genus *Aleurodiphilus* for these rather distinctive species of parasites that, as far as is known, are limited to whiteflies as hosts. This genus appears to resemble *Aspidiotiphagus* most closely but is also very closely related to *Encarsia* as defined by DeBach and LaSalle (1981) and to *Prospaltella* of authors as generally understood before Viggiani and Mazzone (1979) and DeBach and LaSalle (1981). We continue to recognize *Aspidiotiphagus* as valid and do not accept the synonymy of that genus under *Encarsia* as proposed by Viggiani and Mazzone (1979). Reasons for this and recognition characters for *Aspidiotiphagus* are given later.

We recognize that we are dealing with groups that are very closely related and that species exist that currently are difficult to assign. As Hayat (1976) states "It is interesting to note that in the shape, discal setation and longish marginal fringe the aforementioned species [i.e. *Encarsia acaudaleyrodia* Hayat, *E. pergandiella* Howard, *E. parvella* Silvestri, *E. nipponica* Silvestri, and probably also *P. citrofila* Silvestri: authors' addition] resemble some of the species presently in *Aspidiotiphagus* How. (*A. latipennis* Comp.) and also *Prospaltella* Ashm. (*P. nupta* Silv., *P. inserens* Silv., *P. explorata* Silv. and *P. diaspidicola* Silv.), but they differ in the conformation of antennal segments." We agree with Hayat (1976) that *Aspidiotiphagus* and certain *Encarsia* are similar but that they also have significant differences. Additionally, we think it useful to establish the new genus *Aleurodiphilus* in spite of the apparent similarity between certain species of *Aleurodiphilus*, *Aspidiotiphagus*, and *Encarsia*. We, of course, are using *Encarsia* herein as proposed by DeBach and LaSalle (1981) which therefore includes most *Prospaltella* of authors.

Aleurodiphilus DeBach and Rose, NEW GENUS

Based upon study of a number of species and hundreds of specimens, females of this genus generally can be readily recognized as follows: Rather narrow forewing (usually more than $3\times$ as long as wide) usually smoothly and gently curved along posterior margin, presence of a round or oval ase-tose clear area below stigmal vein extending about to mid-disc (similar to *Aspidiotiphagus*), longest posterior marginal fringe of forewing $\frac{1}{2}$ to $\frac{3}{4}$ width of disc, longest anterior marginal fringe of forewing $\frac{1}{3}$ to nearly $\frac{1}{2}$ width of disc, setation of forewing sparse (usually less than 100 setae in disc

distad of a line drawn between stigmal vein and distal end of frenal fold and less than 50 setae basad of this line), 1 seta in hyaline area of wing base and a noticeably distinct row of setae beneath alary fringe that is paired, with rare exceptions, from origin between stigma and margin to apex and past for from $\frac{1}{3}$ distance to completely to distal end of frenal fold. This row of setae set off from discal setae by a linear area free of setae extending around disc. No setae on the dorsal stigmal vein. Hindwing semi-pedunculate. Female antenna 8-segmented, elongate (longer than abdomen), nearly as long as thorax and abdomen combined, from very little to moderate differentiation between funicle and club segments, the 2 club segments broadly joined and usually less than $\frac{2}{3}$ as long as preceding 4 funicle segments combined. All tarsi 5-segmented. Mesoscutum usually with 4–6 setae but with as many as 12 depending on species; reticulate sculpture. Parapsis with 2 setae, axilla with 1. Scutellum with 4 setae and 2 placoid sensilla. Ovipositor short (subequal to hindtibia). Color yellowish to completely fuscous with different degrees and patterns of dusky melanization in integument depending upon species. Melanization pattern, if any, appears very constant for each species and is a good specific diagnostic character. Forewing hyaline except on dark species which have fuscous wing base. Length about 1 mm or less. Parasites of whiteflies.

Male generally dusky, otherwise similar to female except for usual sex differences in antenna and genitalia. Males frequently, perhaps obligatorily, hyperparasitic.

Type-species.—*Aleurodiphilus americanus*, n. sp.

Aleurodiphilus americanus DeBach and Rose, NEW SPECIES

Figs. 1–18

This widespread American biparental parasite of *Aleurothrixus floccosus* (Maskell) can be recognized by possession of the characters given for the genus; by the female's predominantly pale yellow color—having only some faint infuscation evident in some cleared specimens on the mesothoracic and metathoracic sternal areas (Fig. 1) and on the antenna, especially the ultimate segment (Fig. 2); by the pale setae on head, thorax, and abdomen which are essentially invisible at 120 \times under binocular microscope; by the common presence of males which are predominantly dusky except for partial areas of the head and mesoscutum and the entire scutellum; and by the following:

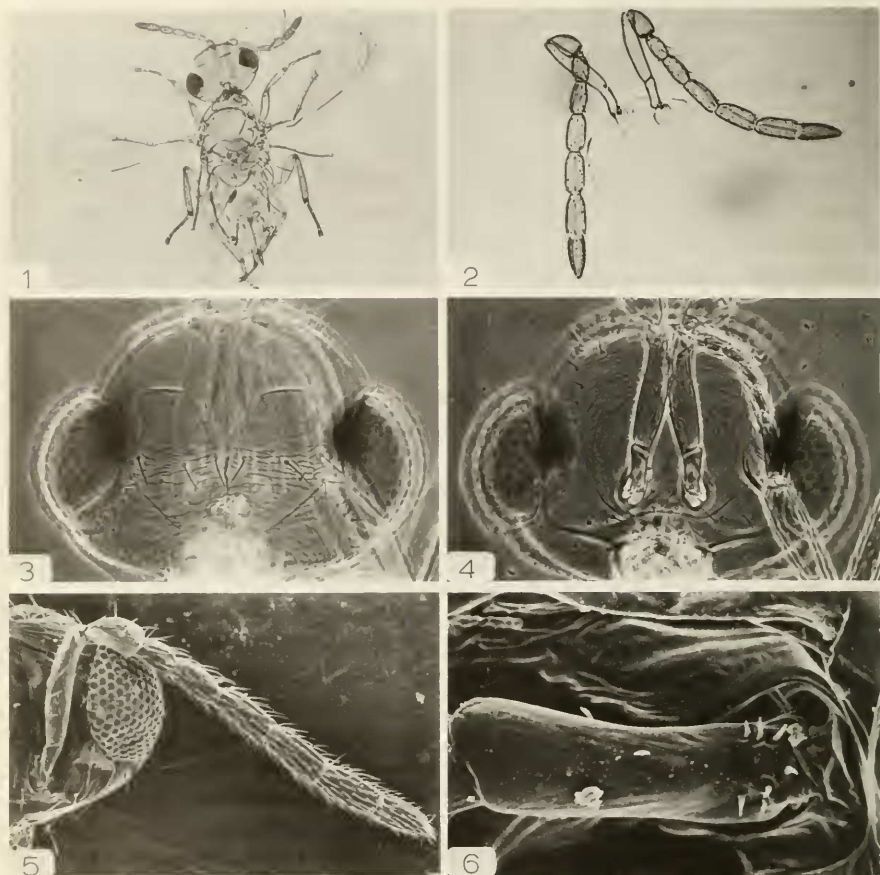
Female.—Head wider than thorax or abdomen, faintly setose (Fig. 1). Under 450 \times phase contrast magnification 20 large setae evident on fronto-vertex; occiput with 20–22 setae (10–11 pairs) ranging in a band between compound eyes and extending behind compound eyes (Fig. 3); face asetose centrally but with 4 setae between antennal bases and 3–4 setae laterally on

each side bordering compound eyes and adjacent to frontovertex (Fig. 4); about 10 setae scattered in a band extending between compound eyes just above mouthparts (Fig. 4); compound eyes very finely setose; triangular suture around ocelli inconspicuously evident; 5 large setae present within ocellar triangle. Mandible well developed, tridentate. Maxillary and labial palpi 1-segmented. Antenna with numerous coarse setae (Fig. 5).

Antenna relatively long and slender, about $0.7\times$ as long as thorax and abdomen together (Figs. 1, 2, 5). Relative proportions of antennal segments (i.e., radicle: scape: pedicel: funicle 1, 2, 3, 4: club 1, 2) as follows: length, 1.0:2.7:1.2:0.9:1.2:1.4:1.5:1.5:1.6; width, 1.0:1.5:1.8:1.5:1.6:1.8:1.9:1.9:1.8. The radicle bears 7 small round specialized sensilla on the basal portion, each with a minute seta (Fig. 6). Each funicle segment usually bears a pair of basiconic sensilla distad; each club segment bears one. Tip of club usually with 3 elongate, finger-like sensilla. Flagellar segments bear longitudinal sensilla (rhinarium) usually according to the formula: 0, 1, 2, 2, 2, 2. The 2 club segments broadly joined; tip of club more or less pyriform (Fig. 7).

Mesoscutum with 4 setae. Scutellum with 4 setae and 2 placoid sensilla. Parapsis with 2 setae, axilla with 1 (Figs. 8, 9). Sculpture on head and thorax very faintly evident only under $450\times$ phase contrast magnification. Vertex without evident sculpture; face very faintly sculptured. Thoracic sculpture reticulate (Fig. 8). Endophragma short, extending to anterior portion of abdominal segment 4. Metanotum long and narrow, about $12.5\times$ as long as wide. Propodeum very narrowly constricted in center. Second abdominal tergum (the tergum immediately posteriad of the propodeum) appears 2-lobed with fine reticulate sculpture laterad (Figs. 8, 10).

Forewing (Fig. 11) narrow, hyaline, no infuscation, about $3\times$ as long as wide; large roundish glabrous area around stigma extending to about mid-disc; marginal vein about $1\frac{1}{3}\times$ as long as submarginal; stigmal vein short, bearing no setae on dorsal surface, closely appressed to margin; longest posterior marginal fringe hairs about $\frac{1}{2}$ width of disc; 2 setae near base of submarginal vein, 10–12 bullae on submarginal vein; usually 6 setae on anterior edge of marginal vein; a single seta in hyaline area of wing base below bullae (Fig. 12); about 5 minute nearly invisible setae occur along or on the submarginal vein in the basal $\frac{1}{2}$ of costal cell (Figs. 11, 12); approximately 100 setae in discal area distad of a line drawn between stigma and distal end of frenal fold and about 50 setae basad of that line; a distinct line of setae encircling wing beneath marginal fringe and rather clearly separate from discal setae proper by a clear streak, the line of setae extends from between stigma and margin around wing to just past proximal end of frenal fold, line of setae double from stigmal area to well past apex, single thereafter (Figs. 11, 13). Hindwing long and narrow, semi-pedunculate, about $8\times$



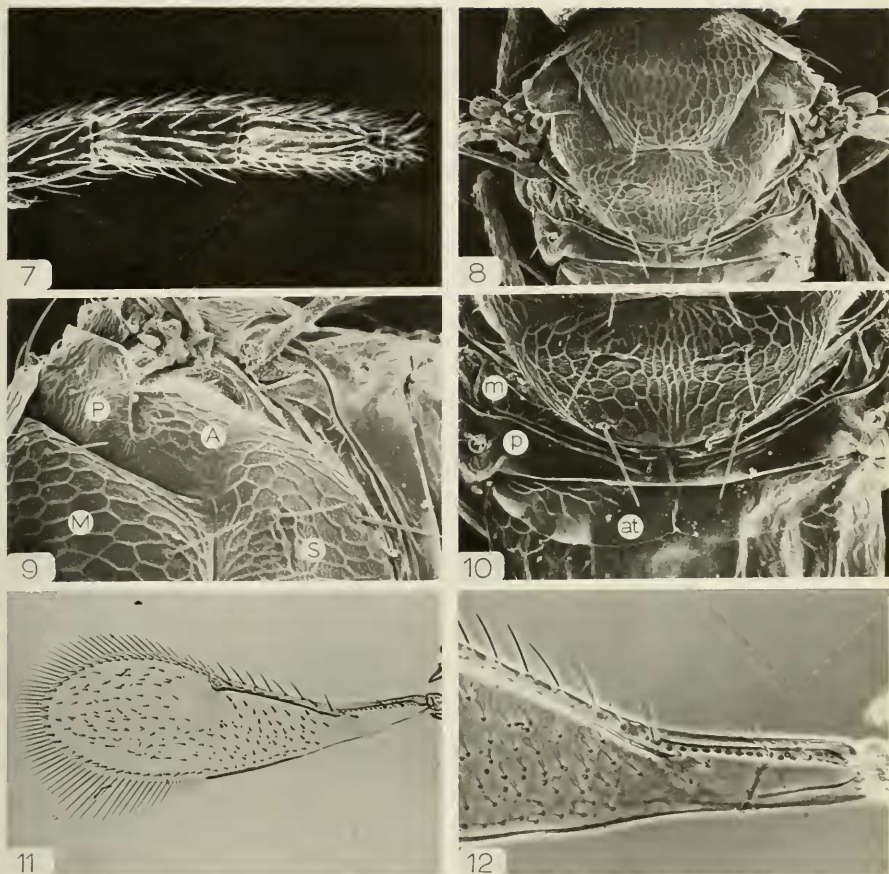
Figs. 1-6. *Aleurodiphilus americanus*, female. 1, Holotype. 2, Antennae. 3, Occiput. 4, Ventral aspect of head. 5, Antenna (SEM). 6, Radical (SEM).

as long as wide, longest fringe hairs about $1.8\times$ width of disc, setation sparse, usually about 35-50 setae on blade (not including fringe and vein setae) (Fig. 14).

Each tarsus 5-segmented, foretarsus noticeably longer than foretibia, mid- and hindtarsi noticeably shorter than corresponding tibiae; first tarsal segment not distinctly elongate on any leg (Figs. 15, 16, 17).

Abdomen dorsally with a pair of prominent setae (phase contrast, $450\times$) laterally on segments 4, 5, and 6; a medial and lateral pair on segment 7, a central pair and a smaller pair, one located near each posterior abdominal spiracle on segment 8 and, on syntergum, 2 pairs near apex (Fig. 16).

Ovipositor short, subequal to middle tibia and only $1.2\times$ as long as the

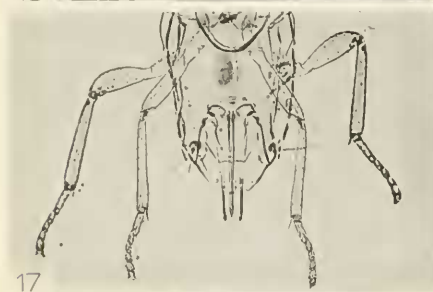
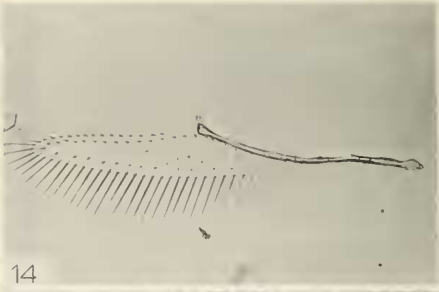
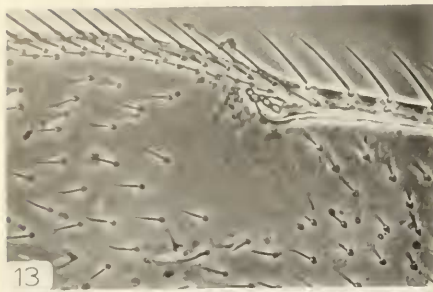


Figs. 7–12. *Aleurodiphilus americanus*, female. 7, Antennal club (SEM). 8, Dorsal aspect of thorax (SEM). 9, Dorsal aspect of thorax (SEM). 10, Dorsal aspect of thorax and abdomen (SEM). 11, Forewing. 12, Forewing base. Abbreviations: A = axilla; at = second abdominal tergum; M = mesoscutum; m = metanotum; P = parapsis; p = propodeum; S = scutellum.

longest cercal seta; broadly separated from endophragma by 0.5 to 0.8 of its own length (Fig. 17).

Length 0.74–0.96 mm.

Male.—Resembles female in general morphology except for usual sexual differences. Color very different from female, integument markedly diffused with black. Posterior margin of head, small areas on the face, anterior $\frac{1}{3}$ of mesoscutum, axillae, propodeum, and abdomen black. Flagellum and marginal vein noticeably dusky. Antenna 8-segmented, about as long as thorax and abdomen together, segments stouter than in female but much less con-



Figs. 13–18. *Aleurodiphilus americanus*. 13, Chaetotaxy and glabrous area of forewing, female. 14, Hindwing, female. 15, Middle tibia and tarsus, female. 16, Dorsal abdomen and hindlegs, female. 17, Ventral abdomen, ovipositor, mid- and hindlegs, female. 18, Antenna, male.

spicuously setose. Pedicel short, about $\frac{1}{2}$ length of any flagellar segment. All 6 flagellar segments bearing numerous longitudinal sensilla, flagellar segments 1–5 appear slightly swollen, ultimate segment noticeably narrower, tapering to a point (Fig. 18). Last 2 segments broadly joined but not fused as in males of *Encarsia tricolor* Foerster and *E. acaudaleyrodidis* Hayat.

Length, 0.65–0.81 mm.

Specimens.—Described from the type-series (25 ♀ and 24 ♂ specimens on 6 slides, reared by P. DeBach and M. Rose, from *Aleurothrix floccosus* (Mask.) on citrus, Santiago (Manzanillo) Colima, Mexico, Jan. 21, 1975.

Additional material from same host on same host plant: Acapulco, Guerrero, Mexico, January 27, 1975, 54♀:14♂ on 6 slides; Cuernavaca, Morelos, Mexico, January 29, 1975, 7♀:7♂ on 2 slides; Oaxaca, Oaxaca, Mexico, January 30-31, 1975, 13♀:8♂ on 2 slides; Veracruz, Veracruz, Mexico, February 3, 1975, 2♀ on 1 slide, near Ciudad Valles, S. L. Potosi, Mexico, 2♀:2♂ on 2 slides; Playa Azul, Guerrero, Mexico, January 25, 1975, 1♀ (the preceding all reared by P. DeBach and M. Rose); near La Paz, Baja California Sur, Mexico, May, 1967, 4♀ on 3 slides, P. DeBach; Culiacan, Sinaloa, Mexico, May 23-24, 1967, 6♀:1♂ on 2 slides, P. DeBach; Mazatlan, Sinaloa, Mexico, May 25, 1967, 3♀:14♂ on 2 slides, P. DeBach; same locality and collector, July 10, 1969, 1♂; Culiacan, Sinaloa, Mexico, July 23, 1970, 1♀:2♂, A. Sanchez Borja; Culiacan, Sinaloa, Mexico, September 23, 1970, 5♀, E. Rios; Rio de Janeiro, Brazil, March 22, 1970, 3♀, P. DeBach; Jacare Paqua, Brazil, May 9, 1971, 4♀ on 2 slides, T. Figueiredo; Queda Hereque, El Salvador, March 8, 1970, 5♀:3♂, J. Quezada.

Type-series in the collection of the Division of Biological Control, University of California, Riverside. Holotype female is at upper center on slide bearing 8 females, the rest are paratypes. The ♂ allotype is the upper center on slide bearing 12♂, the rest are paratypes.

One slide each bearing ♀♂ paratypes of *A. americanus* to be deposited in the U.S. National Museum of Natural History, Washington, D.C.; the British Museum (Natural History), London; the Zoological Institute, Soviet Academy of Science, Leningrad; The Mexican National Museum, Mexico City; and in the collection of the Hebrew University Faculty of Agriculture, Rehovot, Israel. All type-material is from Santiago (Manzanillo), Colima, Mexico.

Notes.—The sex ratio is 2.3♀:1.0♂ based on 300 specimens from Mexico. No pupal cast skin is evident in the whitefly mummy from which *A. americanus* has emerged. There are about four irregularly oval, pale brown meconia evident within the mummy around the sides. The slight amount of ventral pigmentation (see p. 662) evident on most females from Mexico is very uniform for a given area but is imperceptible, for example, in the Brazilian material. We do not consider this to be sufficient grounds for species separation but crossing tests would be helpful in this case. Sibling species may occur as commonly in this genus as in *Aphytis* (see DeBach, 1969). Males have been dissected in incidental checking as hyperparasites on *Amitus spiniferus* Hempel but no thorough studies have been made. *Aleurodiphilus americanus* was introduced from Mexico and colonized in southern California for biological control of woolly whitefly on several occasions between 1967 and 1971 but no recovery was made.

In addition to the new species of woolly whitefly parasite, *Aleurodiphilus americanus*, we find that a previously known species of woolly whitefly parasite, *Encarsia basicincta* Gahan, belongs to *Aleurodiphilus* hence is

designated *Aleurodiphilus basicinctus* (Gahan), NEW COMBINATION. Also, from an examination of the types of *Encarsia pergandiella* Howard, it is evident that this species belongs to *Aleurodiphilus* hence is designated *Aleurodiphilus pergandiellus* (Howard), NEW COMBINATION.

Also, we have in our collection at UCR at least eight new species from whitefly in California and Mexico that clearly fall into *Aleurodiphilus*. These await description. Specimens in our collection from Shikoku, Japan and New Delhi, India, as well as *Encarsia acaudaleyrodia* Hayat, may also prove to belong to *Aleurodiphilus* when sufficiently studied. Finally, it appears possible (although unlikely) from the descriptions that *Encarsia nipponica* Silvestri and *Encarsia parvella* Silvestri may belong under *Aleurodiphilus*.

Aleurodiphilus americanus appears to be very closely related to the previously mentioned parasite of *Aleurothrixus floccosus*, *A. basicinctus* (Gahan), and to *A. pergandiellus* (Howard) which parasitizes *Aleuroplatus* and *Trialeurodes* spp. It differs from *A. basicinctus* (Fig. 19) mainly in the absence of any appreciable melanization pattern in the integument, especially dorsally, and in being arrhenotokous (biparental) whereas *A. basicinctus* evidently is thelytokous (uniparental) based on Gahan's 8 female and no male cotypes from Puerto Rico and our reared collection of 103 *A. basicinctus* females to only 2 males from Florida.

Aleurodiphilus americanus differs from *A. pergandiellus* in having relatively shorter, more compact, female antennae. Those of *A. pergandiellus* (Fig. 20) are about equal to the combined length of the thorax and abdomen; those of *A. americanus* (Figs. 1, 2, 5) are about 0.7 times as long as the thorax and abdomen together. Also those of *A. pergandiellus* are finely setose whereas those of *A. americanus* are more coarsely setose (phase contrast microscope). There are rhinaria on all funicular segments except the first in *A. americanus* whereas there are no rhinaria on funicular segments 1 and 2 in *A. pergandiellus*. The first middle tarsal segment is long and slender in *A. pergandiellus* (Fig. 21), noticeably less so in *A. americanus* (Fig. 15). Comparisons with *A. americanus* were based on Gahan's (1927) description of 8 female cotypes of *A. basicinctus* and on Howard's (1907) description of *A. pergandiellus* and his types (USNM, labeled No. 9321) [the "seven female specimens"—Howard op. cit.—were actually 5 female *A. pergandiellus*, 1 *Eretmocerus* sp. and 1 adult whitefly—authors] as well as a slide bearing 4 females collected and determined as *E. pergandiella* by H. L. Dozier. This material was reared from *Trialeurodes* on perennial verbena, Wilmington, Delaware, November 26, 1927.

Aleurodiphilus is most readily distinguished from *Encarsia* (including *Prospaltella*; the latter as generally used by authors previous to Viggiani and Mazzone (1979) and DeBach and LaSalle (1981)) by the rather large asetose clear area beneath the stigma of the forewing as well as by other

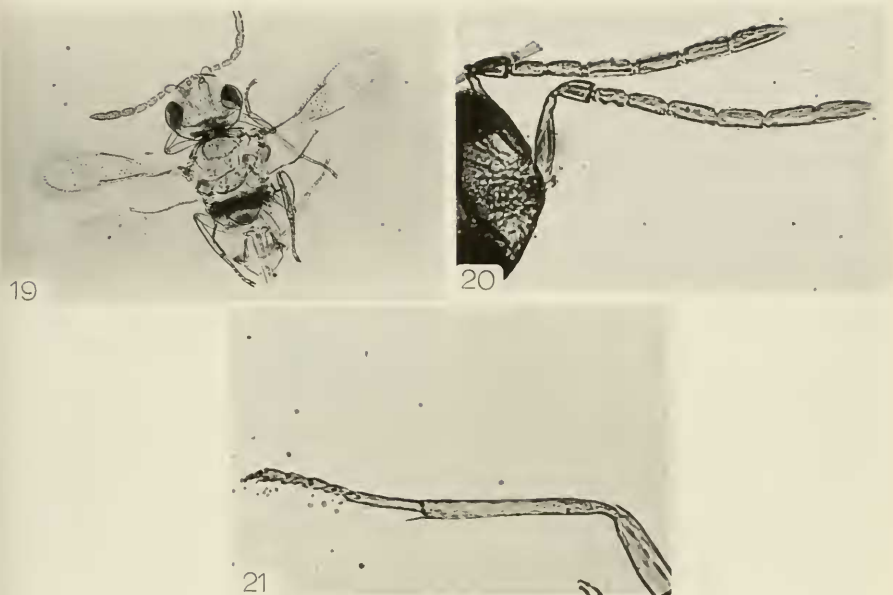


Fig. 19. *Aleurodiphilus basicinctus*, female. Figs. 20, 21. *A. pergandiellus*, USNM type no. 9321, female. 20, Antenna. 21, Middle tibia and tarsus.

comparative characters that follow. We consider the large asetose area beneath the stigma of the forewing to constitute a major generic criterion. There is little or no variation in this character intraspecifically and it is common to species of *Aleurodiphilus* over a wide geographic range.

Certain Asian whitefly parasites in our collection from India, Pakistan, and Japan and the figures and descriptions given in Hayat (1976) and Silvestri (1927, 1930) have a similar asetose area in the forewing as well as 5 segmented tarsi and antennae generally as described for *Aleurodiphilus* but differ somewhat in chaetotaxy of the wing, mesoscutum and/or parapsis. There are also minor differences in the general habitus of the antennae and wings. Further study will be required to determine whether these Asian forms belong to *Aleurodiphilus*, *Encarsia*, or perhaps to a new genus.

Aspidiotiphagus also possesses a similar asetose area in the forewing and the *cubensis* group of *Encarsia* possesses a smaller one (DeBach and Rose, unpublished) but these three genera can be distinguished by other characteristics (see following key).

A similar comparative situation exists between other aphelinid genera. *Aphelinus* and *Aphytis*, for example, both have similar forewings characterized by an asetose area (the speculum) but are distinguished by other characters. It is of interest that originally nearly all *Aphytis* spp. were included under *Aphelinus* as *Aleurodiphilus* has been under *Encarsia*. Other

aphelinid genera rather easily recognized by their forewing setal pattern and/or asetose areas include *Ablerus*, *Azotus*, and *Eretmocerus* among others.

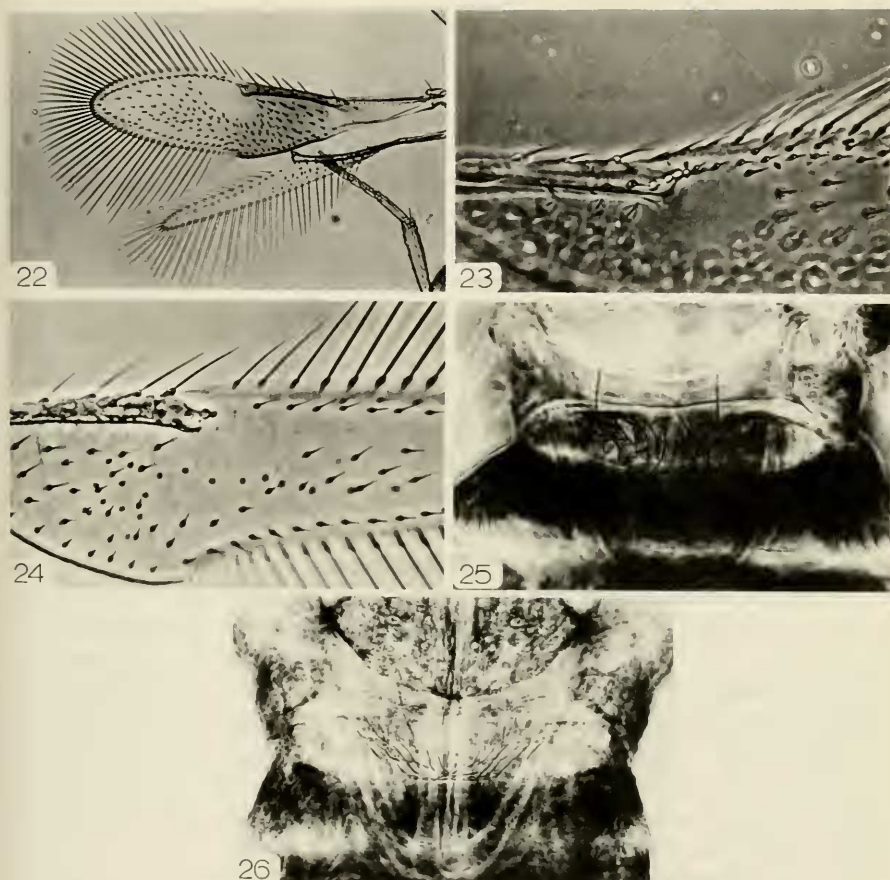
Aleurodiphilus is most easily confused with *Aspidiotiphagus*, in fact, as mentioned, there appear to be very similar forms. Species of *Aspidiotiphagus* generally have more narrow forewings than *Aleurodiphilus* spp. with the posterior margin inflexed (angled) forward at the junction of the disc with the frenal fold (Fig. 22). *Aspidiotiphagus* spp. have fewer setae in the disc (Fig. 22) with the double row of setae (see p. 662) on the inside anterior margin of the forewing originating 1-4 setae distad of the terminus of the stigmal vein (Fig. 23) or with a distinct gap between the terminus of the stigma and the origin of the double row of setae (Fig. 24). This double row of setae does not continuously extend beyond the apex in *Aspidiotiphagus* spp. whereas in all species of *Aleurodiphilus* we examined this double row of setae extends beyond the apex for from $\frac{1}{3}$ to the entire distance to the distal end of the frenal fold. The apex of the forewing is generally more oblately curved in *Aleurodiphilus* spp. than *Aspidiotiphagus* spp. (Figs. 11, 22).

In *Aspidiotiphagus* the greatest length of the posterior marginal setae of the forewing is generally as long as or longer than the width of the disc (Fig. 22) (occasionally only three-fourths as long) whereas in *Aleurodiphilus* it usually ranges only between one-half to three-fourths the width of the disc. The greatest length of the anterior fringe hairs of the forewing in *Aspidiotiphagus* ranges from one-half to more than the width of the disc, whereas in *Aleurodiphilus* it only ranges from one-third to one-half the width of the disc, essentially no overlap in this criterion.

Aspidiotiphagus generally has a 3-segmented club fairly well differentiated from the remainder of the flagellum whereas *Aleurodiphilus* has a largely undifferentiated flagellum, the 2-segmented club is mainly distinguished by the last 2 segments being broadly joined (although this character is often difficult to evaluate in either genus). *Aspidiotiphagus* with 3-segmented clubs generally bear rhinaria only on club segments except for *A. silwoodensis* Alam and *A. cyanophylli* Alam, which are figured (Alam, 1956) with rhinaria on all funicle segments; *Aleurodiphilus* has rhinaria on the club and all funicle segments except 1 and on 2 or 3 depending on species.

All *Aspidiotiphagus* we examined (p. 671) bear distinctive sculpture medially on the second abdominal tergum (the tergum immediately posteriad of the propodeum) (Figs. 25, 26), whereas no equivalent sculpture is evident on any *Aleurodiphilus* species examined (see following rediagnosis of *Aspidiotiphagus* for further detail on the preceding characters).

All known species of *Aspidiotiphagus* are parasites of Diaspididae; all known species of *Aleurodiphilus* are parasites of Aleyrodidae (except the hyperparasitic males, which, as far as we know, parasitize primary parasites within aleyrodids).



Figs. 22-26. *Aspidiotiphagus* spp., females. 22, *A.* sp. ex diaspidid scale from Cyprus, forewing and hindwing. 23, *A.* sp. ex *Aonidiella orientalis* from Saudi Arabia, glabrous area of forewing with double row of setae under margin beginning 3 setae distad of stigmal vein. 24, *A. lounsburyi* (determined H. Compere), glabrous area of forewing with double row of setae under margin beginning after an asetose gap distad of stigmal vein. 25, *A. citrinus* (determined H. Compere), second abdominal tergum. 26, *A. latipennis* (paratype), second abdominal tergum.

Aleurodiphilus, as already mentioned, might also be confused with certain *Encarsia* species we place in the *cubensis* group of *Encarsia* (DeBach and Rose, unpublished). The *cubensis* group has a small glabrous area in the forewing beneath the stigma but is easily distinguished from *Aleurodiphilus* species by having 4-segmented middle tarsi and a 3-segmented club whereas *Aleurodiphilus* has 5-segmented tarsi on all legs and a 2-segmented club. Our *cubensis* group appears to be a natural one and is not the equivalent of Viggiani and Mazzone's (1979) *formosa* group although, along with dissim-

ilar species, they include *E. cubensis* Gahan and *E. quaintancei* Howard in the latter.

The geographical distribution of *Aleurodiphilus* is broad and may turn out to be much greater when additional collections and studies have been made. We have determined from our collections, other museum specimens, and from the taxonomic literature, that species occur in North, Central, and South America and the Caribbean. Our literature survey has not revealed the presence of species in Europe.

REDIAGNOSIS OF *ASPIDIOTIPHAGUS* HOWARD

Coccophagus citrinus Craw, 1891.

Encarsia citrinus Riley and Howard, 1891.

Aspidiotiphagus citrinus Howard, 1894.

Prospaltoides howardi Brèthes, 1914.

Aspidiotiphagus shoeversi Smits van Burgst, 1915.

There is some confusion regarding the type of *Coccophagus citrinus* Craw, the type-species of *Aspidiotiphagus*. When Craw (1891a, b) described *C. citrinus*, reared from *Aonidiella citrina* (Coquillett) (= *Aspidiotus citrinus*) first collected in the San Gabriel Valley in California in 1889, it was placed under *Coccophagus* apparently following Howard's suggestion. Riley and Howard (1891) then placed it as *Encarsia citrinus* (see Compere, 1936, for further detail). This generic designation was later changed by Howard (1894) who erected the new genus *Aspidiotiphagus* for *citrinus* and redescribed this species from 14 female specimens reared from *A. citrina* (Coq.) (= *Aspidiotus aurantii* Maskell, var. *citrinus*) also collected in San Gabriel, California by Coquillett in 1889.

Elsewhere, Brèthes (1914) erected *Prospaltoides* for his new species *howardi* reared from *Pseudaulacaspis* (= *Diaspis*) *pentagona* (Targioni-Tozzetti) in Argentina which he subsequently (Brèthes, 1916) synonymized with *Aspidiotiphagus citrinus*. Mercet (1930) also synonymized *Aspidiotiphagus schoeversi* Smits van Burgst with *A. citrinus*. DeSantis (1948) examined the "type" of "*Prospaltoides howardi* Brèthes" and stated that only two species of *Aspidiotiphagus*, *A. citrinus* and *A. lounsburyi* (Berlese and Paoletti), are present in Argentina, seemingly confirming Brèthes' (1916) synonymy.

Howard did not designate any of the specimens collected by Coquillett in California in 1889 as a holotype when he erected *Aspidiotiphagus* in 1894. Craw's original specimens, also collected in 1889, are apparently lost. There are no specimens from Craw deposited at the U.S. National Museum nor were we able to locate specimens in the collections of the California Academy of Sciences, the University of California, the Los Angeles Natural History Museum, or the California State Department of Food and Agriculture.

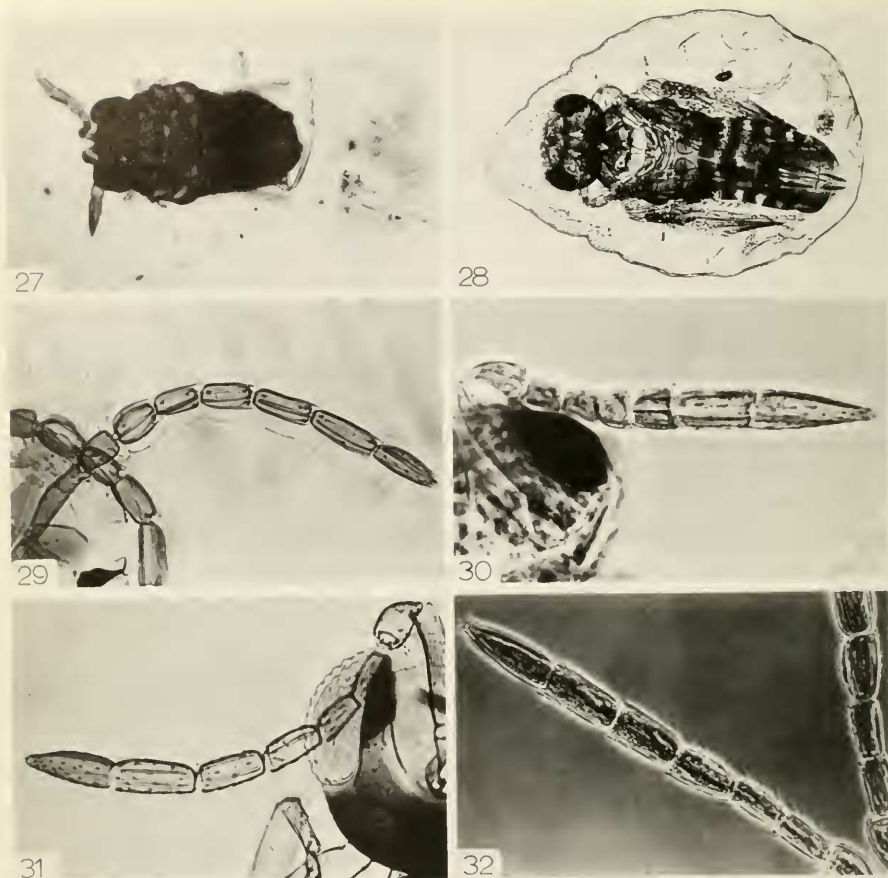
We examined 12 female specimens on three unnumbered slides from the USNM labeled; "*Coccophagus citrinus* Craw from *Aspidiotus aurantii*, Jan. 18, 1889, San Gabriel, Cal." (1 slide), "*Aspidiotiphagus citrinus* Craw bred from *Aspidiotus aurantii* San Gabriel, Cal. Jan. 24, 1889" (1 slide), and "*Aspidiotiphagus citrinus* from *Aspidiotus aurantii* March 13, 1889 San Gabriel, Cal." (1 slide). The data on the USNM slides corresponds with Howard's (1895) statement regarding *Aspidiotiphagus citrinus*, "Redescribed from fourteen female specimens reared January 18 and 24, February 2 and March 13, 1889 by Mr. D. W. Coquillett from *Aspidiotus aurantii*, var. *citrinus*, from San Gabriel, Cal." The last two slides dated January 24 and March 13, 1889 also bear the notation, "Part of original material which formed basis of Howard description in Ins. Life VI, p. 230." Specimens noted by Howard (1895) collected on February 2, 1889 by the same collector on the same host in the same locale were not among the USNM collection we examined.

We have designated a NEOTYPE on the USNM slide dated March 13, 1889 (Fig. 27). The USNM specimens of *Aspidiotiphagus citrinus* are difficult, at best, to study as fine detail is often obscured. However, the characters as given by Howard (1894) can generally be observed and fit the generic description of *Aspidiotiphagus* to follow.

In order to compare *Aspidiotiphagus* with *Aleurodiphilus*, *Encarsia*, and other genera, we have studied, along with the USNM material, the collections of H. Compere, P. DeBach, M. Rose, and others held in the Division of Biological Control, University of California, Riverside. More than 1000 specimens of *Aspidiotiphagus*, including paratypes (*A. flavus*, *A. latipennis*) designated by Compere (1936) and numerous specimens identified by Compere and others, collected from 21 scale insect genera comprising 54 known species and 8 unknown species of Diaspididae from 37 countries throughout the world were examined.

To our knowledge only one species of *Aspidiotiphagus* is recorded from a non-diaspine scale host; *Aspidiotiphagus aleyrodidis* Ashmead (1904), reared from an aleyrodid on sugar-cane in Manila, Philippines. We examined 3 of Ashmead's syntypes (USNM Cat. No. 7354, E. Grissell, personal communication) and found that these point-mounted specimens definitely were not *Aspidiotiphagus* but possibly belong to *Encarsia*. Cleared slide mounts would be necessary for accurate identification.

Thus, all known species of *Aspidiotiphagus* are parasites of diaspidid scales. DeSantis' (1979) very extensive host list for *A. citrinus* and *A. lounsburyi* tends to confirm this. Our host records, rearings and dissections all indicate that *Aspidiotiphagus* are primary, solitary, internal parasites which develop in immature (second-instar) scale bodies (Fig. 28). It is possible that most, if not all, *Aspidiotiphagus* spp. are thelytokous. Males are non-existent or extremely rare in all species studied that had sufficient specimens available to be meaningful. Male *Aspidiotiphagus* spp. we have examined



Figs. 27-32. *Aspidiotiphagus* spp. 27, *A. citrinus*, USNM neotype female. 28, *A. sp.* female inside second-instar *Hemiberlesia lataniae* from California. 29, *A. sp.* near *lounsburyi*, male antenna. 30, *A. lounsburyi* (determined H. Compere), female antenna. 31, *A. sp.* ex *Parlatoria blanchardi* from Israel, female antenna. 32, *A. latipennis* (paratype), female antenna.

greatly resemble the female, the immediately obvious differences being the antennae (Fig. 29) and genitalia.

The current taxonomic status of *Aspidiotiphagus* exemplifies dichotomy of thought. We, as stated earlier, favor retention of *Aspidiotiphagus* as a valid genus as did Hayat (1976). Conversely, Viggiani and Mazzone (1979) place *Aspidiotiphagus* under their proposed *citrina* group of *Encarsia* whereas Alam (1956) divides *Aspidiotiphagus* into two proposed subgenera: *Aspidiotiphagus* Howard subgen. n., type-species *A. citrinus* (Craw) based on "Hairs of marginal fringe of forewing clearly longer than maximum width of disc" and *Paraspidiotiphagus* subgen. n., type-species *A. flavus* Com-

pere based on "Hairs of marginal fringe of forewings not longer than maximum width of disc." Apparently Alam's decisions were made based on descriptions from the literature as well as on the description of his two new species, *Aspidiotiphagus silwoodensis* Alam and *A. cyanophylli* Alam.

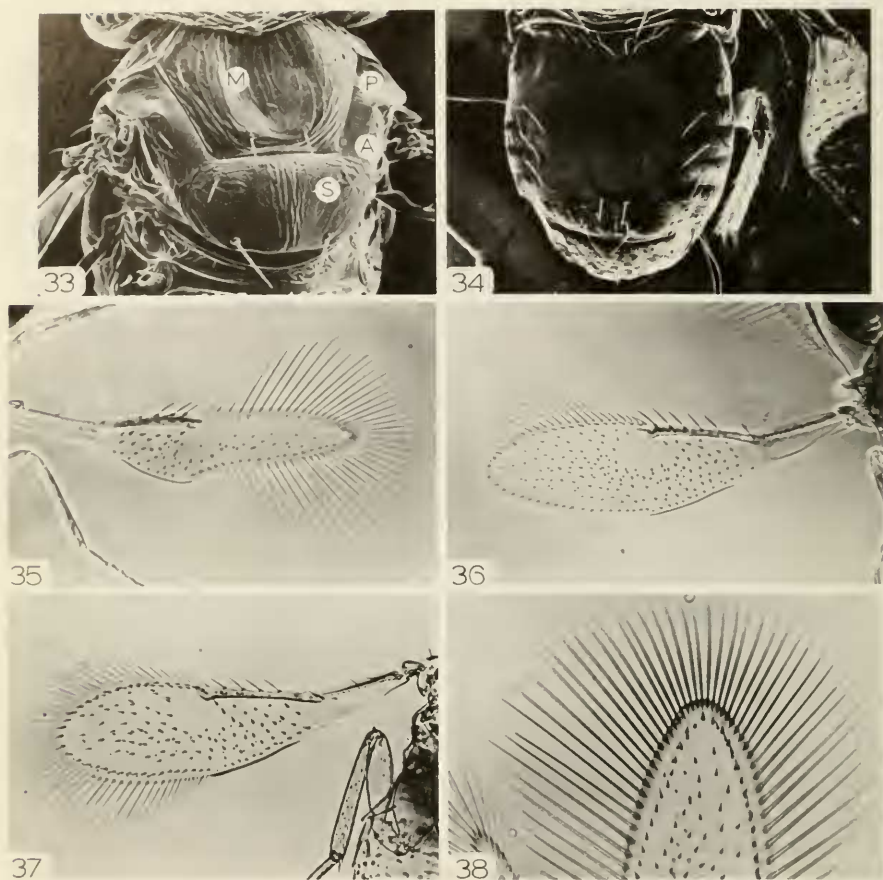
Compere (1936) noted "In this paper two forms [*A. flavus*, *A. latipennis*: authors' addition] are described in which the width of the forewings is greater than the length of the longest marginal fringe." Whether the relative length of the alary fringe of the forewing of various *Aspidiotiphagus* spp. will prove sufficient to support Alam's proposal of subgenera is problematical. We do not now intend to make this determination.

From our examination of the numerous specimens of *Aspidiotiphagus* already mentioned we have found several morphological characteristics which separate this genus from *Aleurodiphilus* and *Encarsia* (see pp. 666, 667) as well as from *Coccophagoides* and *Primaprospaltella*. These characters are given below and in the following key. We also consider that the number of species of *Aspidiotiphagus* is apparently greater than have been described, particularly the fuscous, thelytokous species that are near *citrinus* and which are numerically abundant worldwide.

All *Aspidiotiphagus* we examined are adequately described in habitus by Craw (1891a, b), Howard (1894), Brèthes (1914), Mercet (1930), Compere (1936) and DeSantis (1948). Howard's (1894) generic description states, "club long, distinctly three jointed." However, *A. fuscus* Compere (1936, Fig. 8) differs in having the 4 ultimate segments enlarged with the 5 ultimate antennal segments bearing rhinaria. We have observed similar antennae in other, undescribed *Aspidiotiphagus*. *Aspidiotiphagus* would be more fittingly characterized as generally having a 3-segmented club, ranging in appearance from first club segment reduced as in *A. lounsburyi* (Fig. 30), with rhinaria only on the club segments (except *A. silwoodensis* Alam and *A. cyanophylli* Alam), to antennae with 4 ultimate segments enlarged with rhinaria on the 4 ultimate antennal segments and occasionally on 5 ultimate antennal segments (Figs. 31, 32).

All species of *Aspidiotiphagus* we examined bear 1 seta on the parapsis and axilla, 2-6 setae on mesoscutum, 4 setae on scutellum (Compere's (1936) record of 6 setae on scutellum of *flavus* is apparently incorrect) (Fig. 33) and, in most specimens, 4 dorsal setae on abdominal terga 7 and 8 and on the syntergum. The dorsal surface of the posterior abdominal terga usually is stippled, often most conspicuously on the syntergum (Fig. 34). All tarsi are pentamerous.

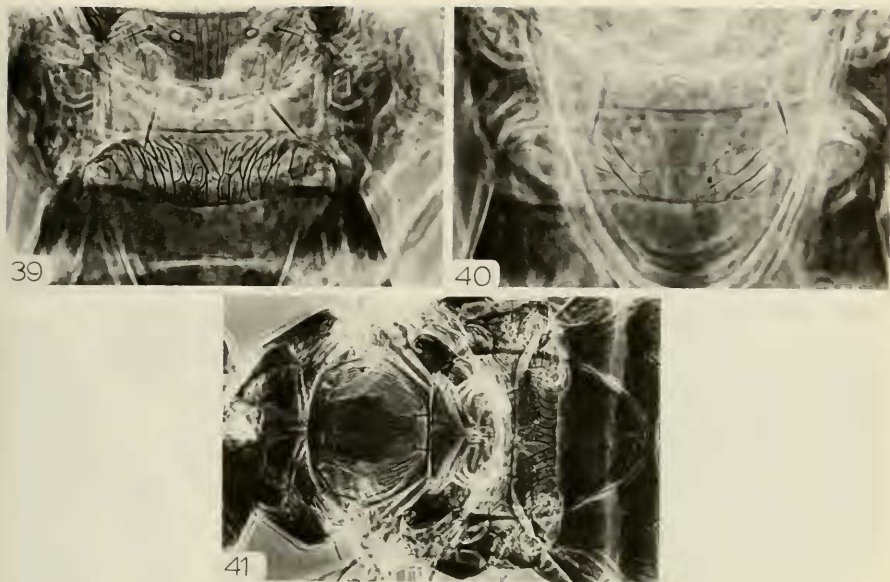
The inflexed wing, with a glabrous area surrounding the stigmal vein, has been characterized above and ranges in degree of inflection from *lounsburyi* (Fig. 35) to *flavus* (Fig. 36) with the other described species and undescribed specimens of *Aspidiotiphagus* grading between these species. *Aspidiotiphagus flavus* Compere (Fig. 36) has the least inflexed wing of those species



Figs. 33-36, 38. *Aspidiotiphagus* spp., females. 33, *A.* sp. ex *Hemiberlesia lataniae* from California, dorsum of thorax. 34, *A.* sp. as Fig. 33, dorsum of abdomen. 35, *A. lounsburyi* (determined H. Compere), forewing. 36, *A. flavus* (paratype), forewing. 37, *Aleurodiphilus basicinctus* female. 38, *Aspidiotiphagus* sp. ex diaspidid scale from Cyprus, apex of forewing. Abbreviations: A = axilla; M = mesoscutum; P = parapsis; S = scutellum.

described by Compere (1936) and is somewhat similar in general habitus to *Aleurodiphilus basicinctus* (Gahan), which has the most extremely inflected wing in our collection of *Aleurodiphilus* (Fig. 37) and is somewhat more inflexed than the forewing of *Aleurodiphilus americanus* (Fig. 11). The apical margin in *Aleurodiphilus* spp. is generally more oblatly rounded than in *Aspidiotiphagus* spp. (Figs. 11, 22, 35, 36, 37, 38).

In all specimens of *Aspidiotiphagus* examined the forewing between the submarginal and marginal veins and the frenal fold is fuscous (least conspicuous in *A. flavus* paratypes) and bears one seta in the wing base with

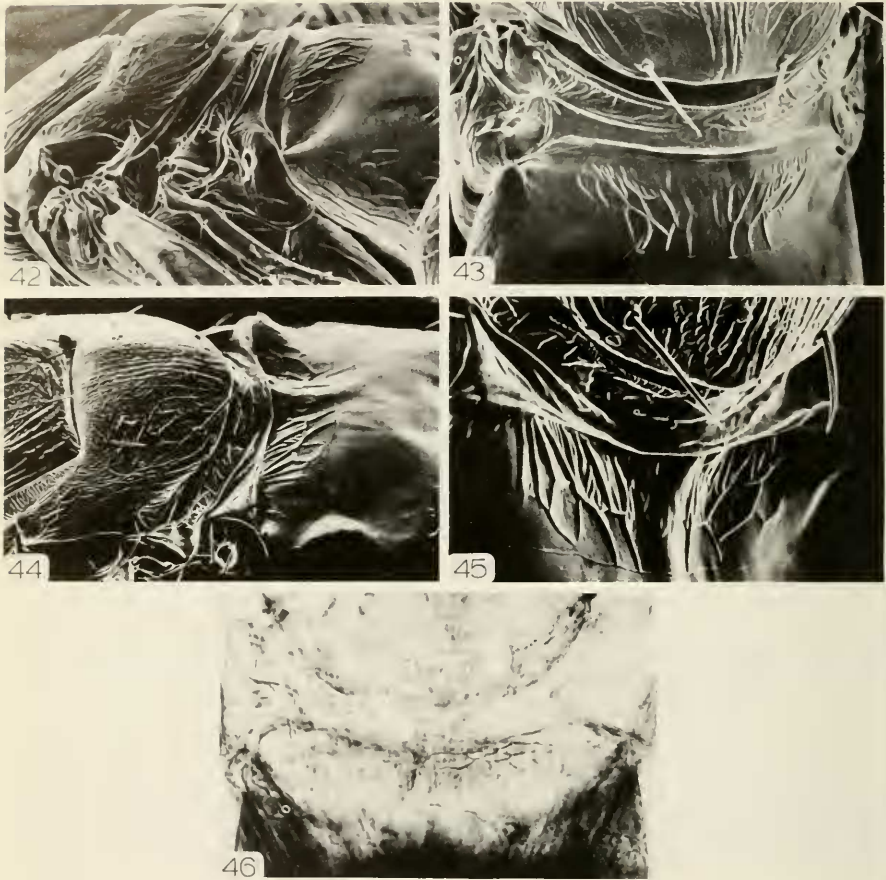


Figs. 39–41. *Aspidiotiphagus* spp., females. 39, *A. sp.* ex diaspidid scale from Australia, second abdominal tergum. 40, *A. sp.* ex *Aonidiella orientalis* from Saudi Arabia, second abdominal tergum. 41, *A. sp.* ex diaspidid scale from the Dominican Republic, second abdominal tergum, dorsum of thorax and anterior abdomen, endophragma.

no setae on the dorsal surface of the stigmal vein (Fig. 22). The double row of setae (see p. 669) on the forewing begins at variable distances from the terminus of the stigmal vein, often after an asetose "gap" (Figs. 23 and 24), and does not extend beyond the apex of the forewing but rather becomes a single row, often with large spaces between setae, at the apex. Thereafter a double row may again commence for a short distance (Fig. 38).

A striking and possibly unique character to distinguish *Aspidiotiphagus* is the characteristic medial sculpture on the second abdominal tergum (see p. 669). In all specimens examined this character is evident and is readily observed at low (100 \times) to high (400 \times) magnifications under the phase contrast microscope, even on damaged specimens. Compere's (1936) Figure 9, page 298, of "*Aspidiotiphagus fuscus* n. sp. Female" and Figure 10, page 300, of "*Aspidiotiphagus flavus* n. sp. Female" suggests this structure but he didn't use it as a character.

This normally longitudinally elongate reticulate sculpture is located medially (Figs. 24, 26) but can encompass nearly the width of the second abdominal tergum (Fig. 39). The type and degree of sculpture ranges in appearance (phase contrast microscope) from delicately light (Fig. 40) to bold and distinct (Fig. 41). Sculpture-type is reasonably constant within



Figs. 42-45. *Aspidiotiphagus* spp., females. 42, *A. sp. ex Hemiberlesia lataniae* from California, thorax and abdomen to show second abdominal tergum, lateral aspect (SEM). 43, Same specimen as Fig. 42, scutellum, metanotum, propodeum, and second abdominal tergum, dorsal aspect (SEM). 44, 45, *A. sp. ex Aonidiella aurantii* from People's Republic of China, as Figs. 42, 43 (SEM). 46, *Encarsia diaspidicola*, USNM cotype no. 41387, female, thorax and abdomen, dorsal view.

conspecific series and could eventually prove useful in species determination. Examination of this structure with a Joel JSM 35C scanning electron microscope showed the sculpture to consist of reticulations formed by sharply raised, longitudinal ridges with smaller longitudinal ridges within the reticulations (Figs. 42, 43, 44, 45).

No such sculpture is evident on any of the *Aleurodiphilus* spp. in our collection. Only *Encarsia diaspidicola* (Silvestri) (= *P. diaspidicola* Silvestri) (Silvestri, 1930) shows any close semblance of such sculpture of all the

hundreds of specimens of *Encarsia* we have examined. However, on *E. diaspidicola*, USNM cotypes, No. 41387, the sculpture of the second abdominal tergum is neither longitudinally elongate nor medially placed (Fig. 46).

Craw (1891a, b) pointed out that *Aspidiotiphagus citrinus* from *Aonidiella citrina* Coquillett failed to reproduce on *Aonidiella aurantii* (Maskell). Compere (1936) later states, "attempts to propagate *Aspidiotiphagus citrinus* upon red scale, *Chrysomphalus aurantii* (Maskell) [*Aonidiella aurantii* (Mask.): authors' addition], have corroborated Craw's contention that this coccid is not a host of the parasite in question."

Such host specificity by a primary thelytokous parasite between two such closely allied hosts (*A. citrina* and *A. aurantii*) that were sympatric and often found on the same host plant in southern California (DeBach et al., 1978) strongly indicates that the actual host range is very narrow, particularly when backed by laboratory tests as is the case presented here. Such oligophagous and possibly monophagous host selection is a good species indicator under biosystematic criteria.

We have observed numerous small differences in the habitus, pigmentation, antennae, chaetotaxy, wing form and sculpture (both generally and on the second abdominal tergum) on numerous specimens of *Aspidiotiphagus* reared from different species of diaspid scales worldwide, including many specimens called *A. citrinus* by various authors. These differences are reasonably constant in series of specimens from a given host species, locale and collection date, hence more than one species may be represented. However, as has been demonstrated with thelytokous species, sibling species, and "forms" of *Aphytis* (DeBach, 1969; Rössler and DeBach, 1972a, b, 1973; Rosen and DeBach, 1979) determination of specific status in such cases requires considerable biological, ecological and behavioral study. For *Aspidiotiphagus* this remains in the future.

KEY TO PENTAMEROUS AND HETEROMEROUS PROSPALTELLINAE

1. Six setae on scutellum; hypogynium present *Coccophagoides*
- Four setae on scutellum; hypogynium absent 2
2. Maxillary palpus 2-segmented; submarginal vein distinctly longer than marginal vein; more than 10 setae in basal area of forewing below bullae; flagellar segments highly differentiated, flagellum rather short and stout; distinctive 3-segmented club *Primaprospaltella*
- Maxillary palpus 1-segmented; propodeum narrowly constricted medially, shorter medially than metanotum; submarginal vein subequal to marginal vein; less than 10 setae in basal area of forewing below bullae; flagellar segments little differentiated, flagellum gen-

- erally long and narrow; club variable, undifferentiated to 4 ultimate segments enlarged 3
3. Wing without glabrous area beneath stigma *Encarsia*
- Wing with glabrous oval or circular area beneath stigma 4
4. Midtarsus tetramerous, others pentamerous; forewing not narrow, about 2.5× as long as wide; *cubensis* group *Encarsia*
- Each tarsus pentamerous; forewing narrow, usually more than 3× as long as wide 5
5. Second abdominal tergum distinctly sculptured medially; antennal club generally 3-segmented, can appear 4-segmented; 1 seta on parapsis; longest forewing anterior-fringe setae ½ to 1-plus times as wide as disc; longest forewing posterior-fringe setae ¾ to 1-plus times as wide as disc; forewing usually distinctly inflexed posteriorly (Figs. 22–45) *Aspidiotiphagus*
- Second abdominal tergum without sculpture medially; antennal club 2-segmented; 2 setae on parapsis; longest forewing anterior-fringe setae ⅓ to ½ width of disc; longest forewing posterior-fringe setae ½ to ¾ width of disc; forewing more or less smoothly curved along posterior margin (Figs. 1–18) *Aleurodiphilus*

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LITERATURE CITED

- Alam, S. M. 1956. The taxonomy of some British aphelinid parasites (Hymenoptera) of scale insects (Coccoidea). *Trans. R. Entomol. Soc. Lond.* 108(8): 357–383.
- Ashmead, W. H. 1904. Descriptions of new genera and species of Hymenoptera from the Philippine Islands. *Proc. U.S. Natl. Mus.* 28(1387): 127–158.
- Brèthes, J. 1914. Les ennemis de la "Diaspis pentagona" dans La Republique Argentine. *Nunquam Otiosus* 1: 12–14.
- . 1916. Hyménoptères parasites de L'Amérique Meridionale. *An. Mus. Argent. Cien. Nat. Bernardino Rivadavia* 27: 401–430.
- Compere, H. 1936. Notes on the classification of the Aphelinidae with descriptions of new species. *Univ. Calif. Publ. Entomol.* 6(12): 277–322.
- Craw, A. 1891a. Internal parasites discovered in the San Gabriel Valley; recommendations and notes. *Bull. Calif. St. Bd. Hort.* No. 57, pp. 3–7.
- . 1891b. Destructive insects, their natural enemies, remedies and recommendations. *Calif. St. Bd. Hort. Div. Entomol.*, pp. 28–29.
- DeBach, P. 1969. Uniparental, sibling and semi-species in relation to taxonomy and biological control. *Isr. J. Entomol.* 4: 11–28.
- DeBach, P., R. M. Hendrickson, Jr., and M. Rose. 1978. Competitive displacement: Extinction of the yellow scale, *Aonidiella citrina* (Coq.) (Homoptera: Diaspididae), by its ecological

homologue, the California red scale, *Aonidiella aurantii* (Mask.) in southern California. *Hilgardia* 46(1): 1-35.

- DeBach, P. and J. LaSalle. 1981. The taxonomic status of *Encarsia*, *Prospaltella*, and *Trichaporus* and a description of *Primaprospaltella*, new genus (Hym., Chalcidoidea, Aphelinidae). *Proc. Entomol. Soc. Wash.* 83(4): 642-657.
- DeSantis, L. 1948. Estudio Monografico de los Afelinidos de la Republica Argentina (Hymenoptera, Chalcidoidea). *Rev. Mus. La Plata Secc. Zool.* 5: 223-232.
- . 1979. Catalogo de los himenopteros chalcidoideos de America al Sur de los Estados Unidos. *Com. Invest. Cien. Prov. Buenos Aires.* 488 pp.
- Gahan, A. B. 1927. Miscellaneous descriptions of new parasitic Hymenoptera with some synonymical notes. *Proc. U.S. Natl. Mus.* 71(4): 1-39.
- Girault, A. A. 1915. Australian Hymenoptera Chalcidoidea—VII. Encyrtidae. *Mem. Queensl. Mus.* IV, 184 pp.
- Hayat, M. 1976. Two new species of Aphelinidae [Hym.: Chalcidoidea] parasitic on *Acaudaleyrodes rhachipora* [Hom.: Aleyrodidae] from India. *Entomophaga* 21(2): 157-162.
- Howard, L. O. 1894. The hymenopterous parasites of the California red scale. *Insect Life* 6(3): 227-236.
- . 1895. Revision of the Aphelininae of North America. U.S. Dep. Agric. Div. Entomol. Tech. Ser. 1, 44 pp.
- . 1907. New genera and species of Aphelininae, with a revised table of genera. U.S. Dep. Agric. Bur. Entomol. Tech. Ser. 12(4): 69-88.
- Mercet, R. G. 1930. Los Afelinidos de España. Segunda Parte. *Rev. Biol. For. Limnol., Ser. B.,* 2: 29-107.
- Riley, C. V. and L. O. Howard. 1891. Special notes. *Insect Life* 4: 163-168.
- Rosen, D. and P. DeBach. 1979. Species of *Aphytis* of the world (Hymenoptera: Aphelinidae). Dr. Junk BV, The Hague, Ser. Entomol., Vol. 17, 801 pp.
- Rössler, Y. and P. DeBach. 1972a. The biosystematic relations between a thelytokous and an arrhenotokous form of *Aphytis mytilaspidis* (LeBaron) (Hymenoptera: Aphelinidae). I. The reproductive relations. *Entomophaga* 17(4): 391-423.
- . 1972b. The biosystematic relations between a thelytokous and an arrhenotokous form of *Aphytis mytilaspidis* (LeBaron) (Hymenoptera: Aphelinidae). II. Comparative biological and morphological studies. *Entomophaga* 17(4): 425-435.
- . 1973. Genetic variability in a thelytokous form of *Aphytis mytilaspidis* (LeBaron) (Hymenoptera: Aphelinidae). *Hilgardia* 42(5): 149-176.
- Silvestri, F. 1927. Contribuzione alla conoscenza degli Aleurodidae (Insecta: Hemiptera) viventi su citrus in Estremo Oriente e dei loro parassiti. *Boll. Lab. Zool. R. Istituto Superiore Agric. Portici* 21, 60 pp.
- . 1930. Contributo alla conoscenza della specie Orientali del genera *Prospaltella* (Hym., Chalcidae). *Boll. Lab. Zool. R. Istituto Superiore Agric. Portici*, 25, 68 pp.
- Viggiani, G. and P. Mazzone. 1979. Contributi all conoscenza morfobiologica della specie del complesso *Encarsia* Foerster—*Prospaltella* Ashmead (Hym., Aphelinidae). I. Un commento sulli attuale stato, con proposti sinonimiche e descrizione di *Encarsia silvestrii* n. sp., parassita di *Bemisia citricola* Gom. Men. (Hom., Aleyrodidae). *Boll. Lab. Ent. Agric. Silvestri* 36: 42-50.